GEM tracking system of the BM@N experiment

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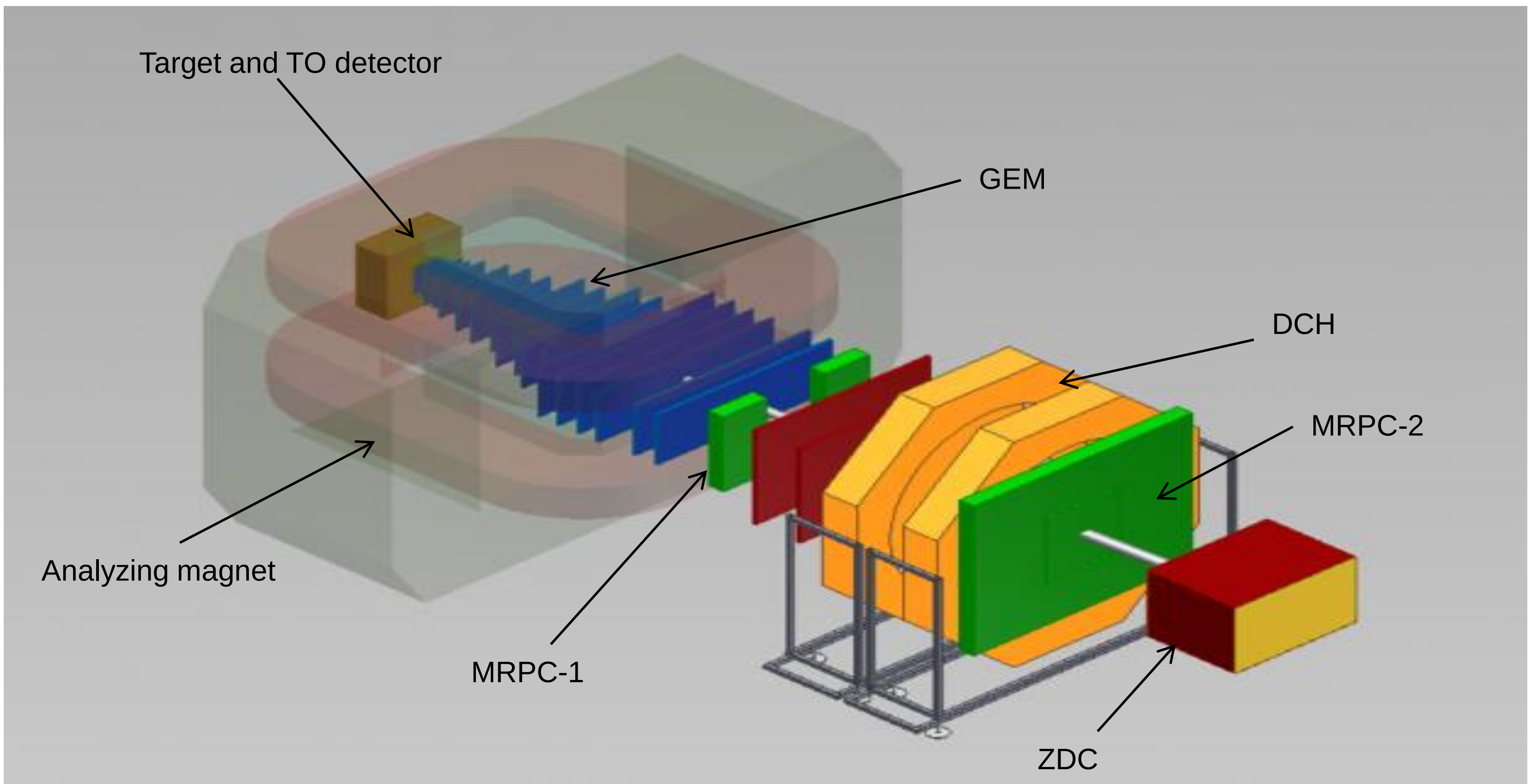
BM@N experiment

Collisions of Nuclotron heavy ion beams with fixed targets provide a unique opportunity to study strange mesons and multi-strange hyperons close to the kinematic threshold. One of the main goals of the experiment is to measure yields of light hyper-nuclei, which are expected to be produced in coalescence of Λ-hyperons with nucleons.



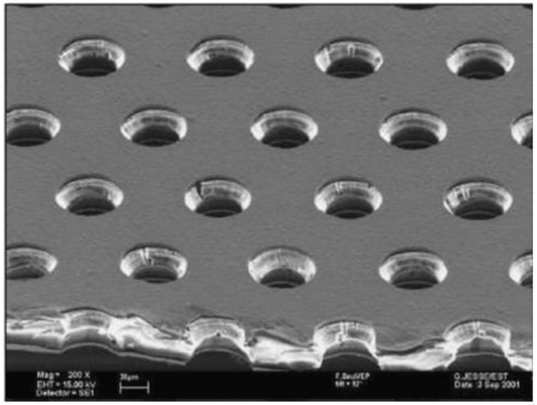
Basic requirements for the BM@N tracking system

Tracking system of the BM@N experiment will provide precise momentum measurements of the cascade decays products of multi-strange hyperons and hyper-nuclei produced in central Au-Au collisions. All physics measurements will be performed in conditions of high beam intensities in collisions with large multiplicity of charged particles. This requires the use of detectors with the capacity to resolve multi tracks produced at very high rate.

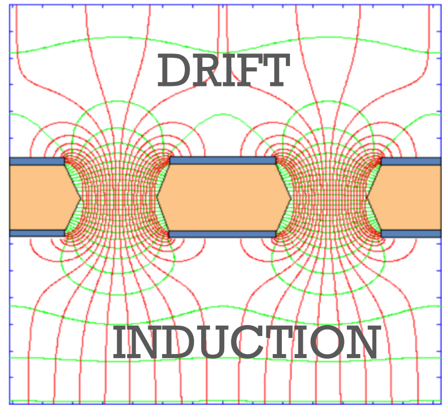
The basic requirements for the tracking system are:

- capability of stable operation in conditions of high radiation loadings up to 10^5 Hz/cm^2;
- high spatial and momentum resolution;
- high geometrical efficiency (better than 95%);
- good timing resolution (5-10ns);
- maximum possible geometrical acceptance within the BM@N experiment dimensions;
- tracking system detectors must function in a 0.8 T magnetic field.

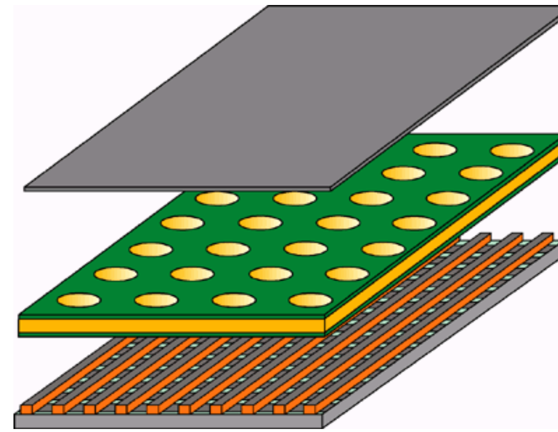
The gas electron multiplier (GEM)



Electron microscope picture of a section of typical GEM electrode, 50 mm thick. The holes pitch and diameter are 140 and 70 mm, respectively.



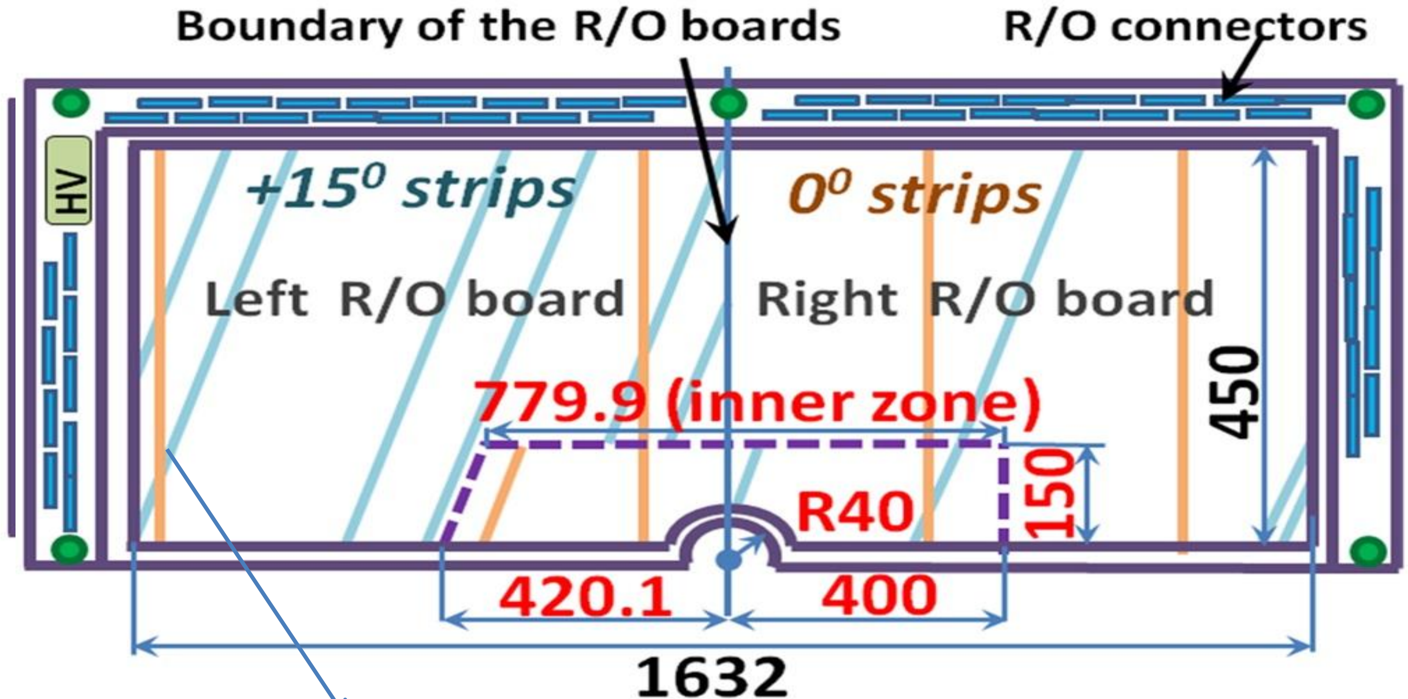
Electric field in the region of the holes of a GEM electrode

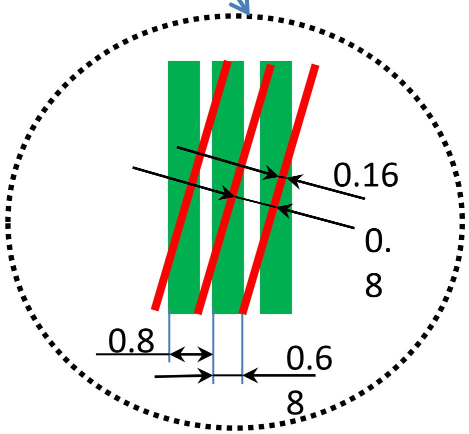


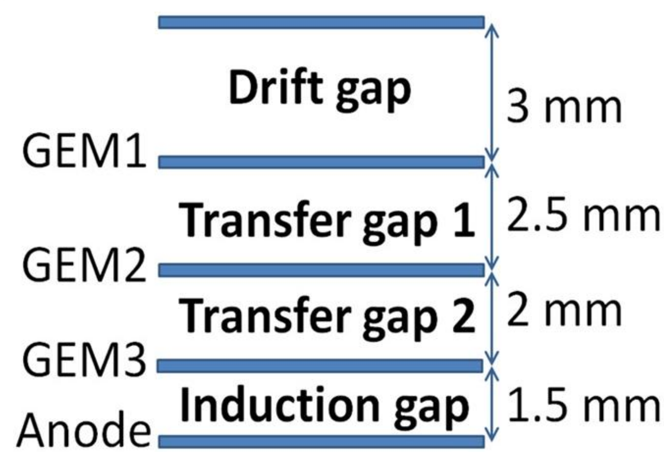
Schematics of single GEM detector with Cartesian two-dimensional strip readout.

Unlike other gaseous counters, the (negative) signal on the anode is generated only by the collection of electrons, without a contribution from the slow positive ions, making the device potentially very fast and minimizing space charge problems.

BM@N GEM 1632x450 sm^2 chambers



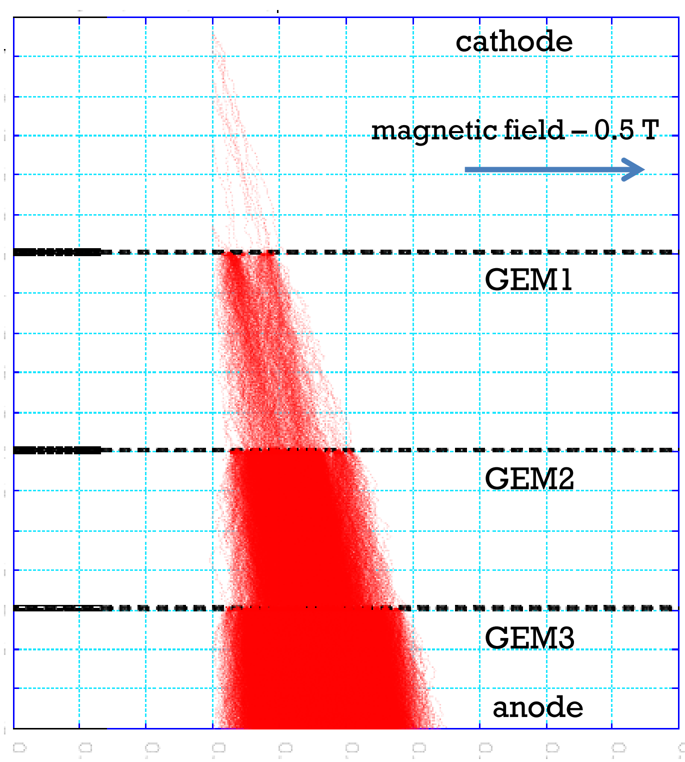




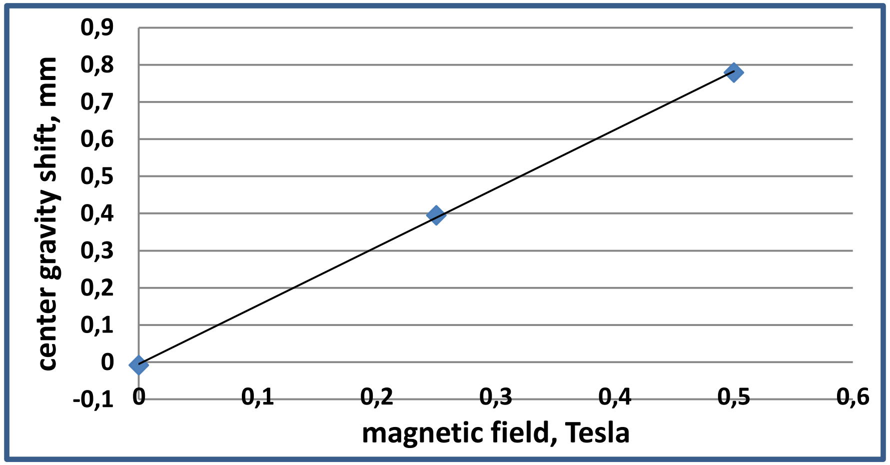
GEM assembly at CERN Workshop

Electrons drift due to magnetic field (Garfield & Maxwell simulations)

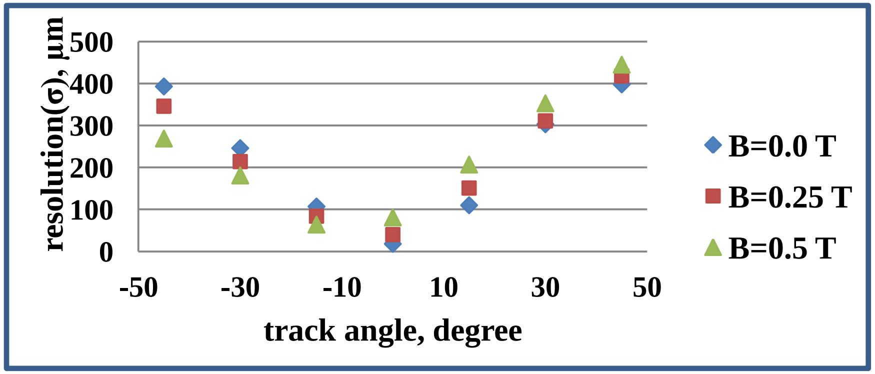
Simulation of electron shift in magnetic field



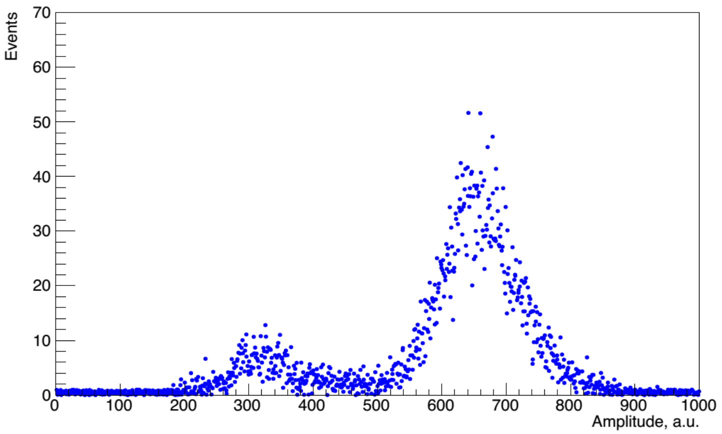
Center gravity shift vs magnetic field



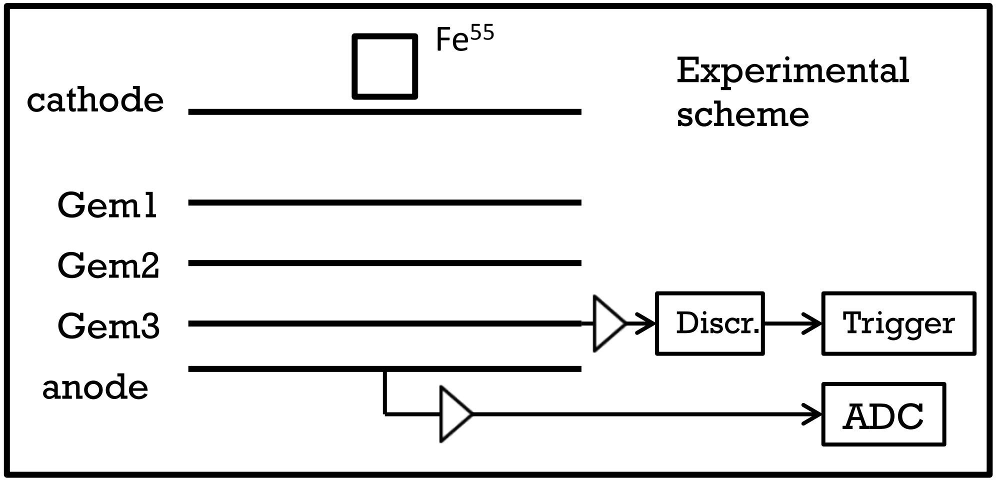
Space resolution vs magnetic field and track angle

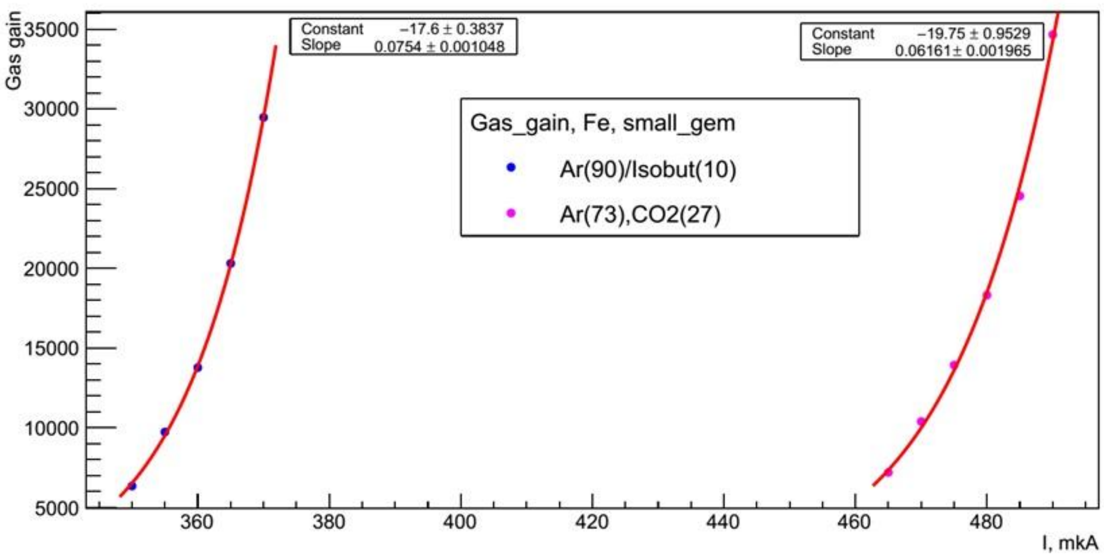


GEM gas gain measurements



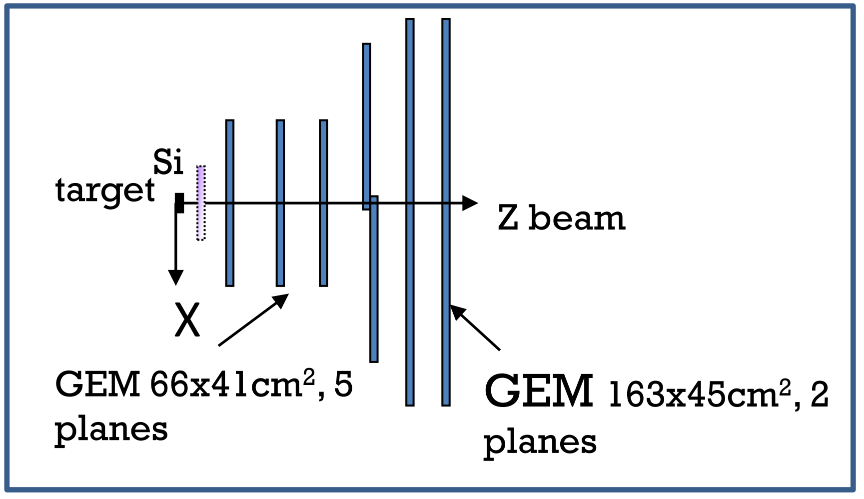
Amplitude distribution, Ar(70)/CO2(30), Fe^{55}



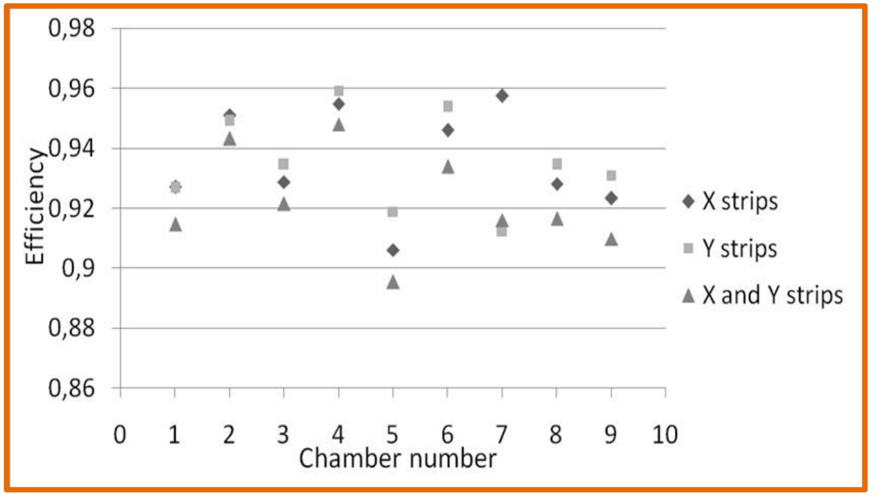


GEM gas gain for Ar(70)/CO2(30) and Ar(90)/Isobutane(10) gas mixtures

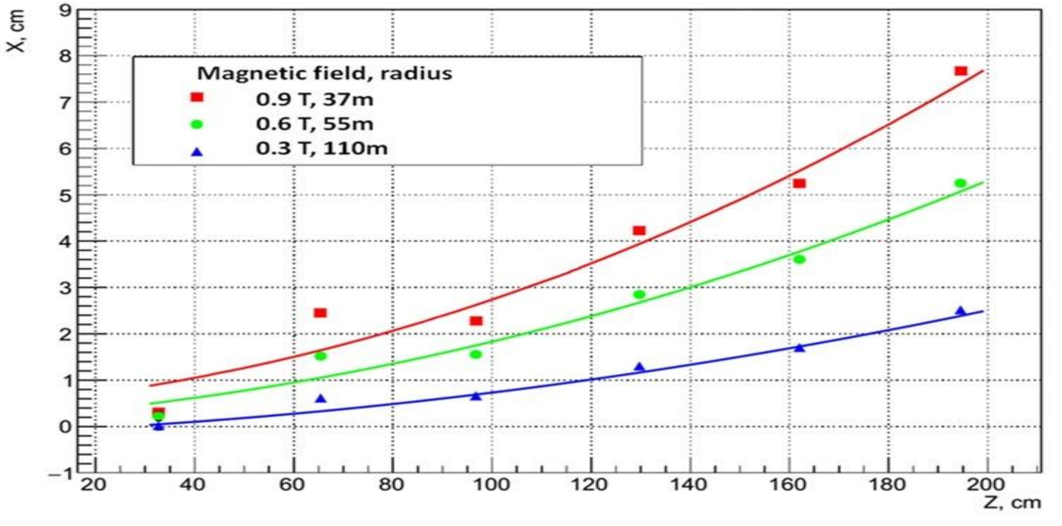
GEM tests at Nuclotron deuteron beam



GEM configuration



GEM efficiencies

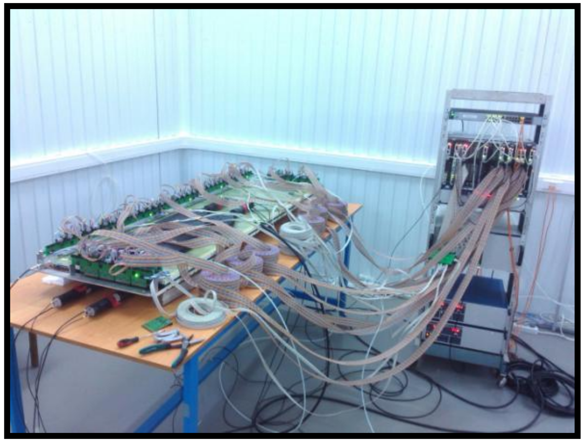


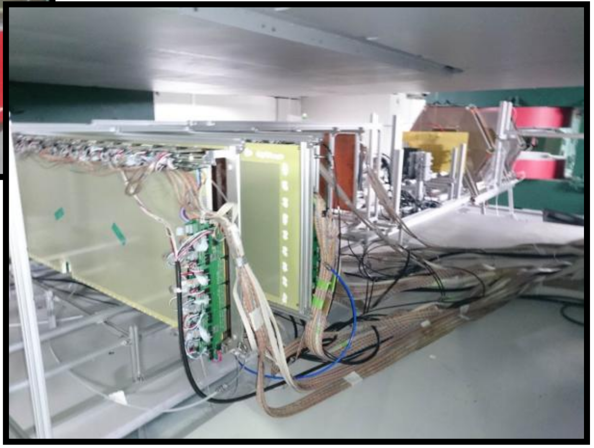
The average trajectories of the deuteron beam and the average Lorentz shifts of an electron avalanche in 6 GEM planes measured for three values of the magnetic field.

Conclusions

Seven triple GEM detectors of the BM@N tracker system have been assembled and studied in the deuteron beam of the Nuclotron accelerator. The measured parameters of the GEM detectors are consistent with the design specifications. Two GEM chambers with the size of 1632 cm × 450 cm are the biggest GEM detectors produced in the world for today.

GEM 1632x450 sm^2 chamber tests at clean room





7 GEM chambers integrated into BM@N experimental setup